SEPARATION OF SILT AND WATER

This invention relates to the separation of silt and water. The invention is particularly concerned with the drying of inorganic slurries such as may result from washing of sand and gravel, and in particular the washing of building sand, which results in the washing water bearing a burden of silt.

Freshly won sand or gravel is typically mixed with argillaceous material and this has to be removed from the sand or gravel before that sand or gravel is incorporated into concrete in a building or other civil engineering structure. If the argillaceous material is not removed from the sand or gravel, this severely weakens the concrete with potentially disastrous results. The practice has accordingly arisen of washing the sand or gravel to remove the argillaceous material. Because of its grain size, sand or gravel tends to settle quite quickly in the washing water and can easily be removed and the process results in a body of washing water carrying a burden of argillaceous silt.

It is also known to manufacture sand or other building material by crushing rock, and it is known to wash the crushed material to remove dust. Again, the result is water loaded with fines. Similarly, soil washing operations and certain quarrying applications result in the formation of a slurry.

Hitherto such a slurry has been supplied to settling lagoons where the silt is allowed to settle out over a period of time, whereafter the then silt free water can be discharged from the lagoon to the environment or for re-use.

This settling process takes a considerable period of time and the settling lagoons occupy a substantial area of land. Both of these factors are disadvantages.

It is an object of the present invention to provide a method of and apparatus for settling silt from water in which these disadvantages are alleviated.

According to the present invention there is provided apparatus for separating silt from water which comprises a settling tank having an inlet section, inlet means comprising an inlet conduit leading to a pre-reaction vessel which communicates at its base with the inlet section of the settling tank, said inlet conduit being valved and the apparatus being equipped with dosing means for the addition of flocculant to an inlet portion thereof, removal means for removing settled material from the inlet section of the tank and means for sweeping settled material along the tank from an outlet section thereof towards such inlet section, and an outlet for the discharge of water over weir means.

The invention includes sand or gravel washing apparatus comprising a washing tank, means for supplying said washing tank with sand or gravel and washing water, removal means for removing the settled sand or gravel from an inlet section of the tank and means for sweeping the settled sand or gravel along the tank from an outlet section thereof towards such inlet section, and an outlet for the discharge of silt and water to a settling apparatus for separating silt from water as herein defined.

The invention extends to a method of separating silt from water which comprises passing a silt/water mixture to an inlet section of a settling tank via an inlet conduit leading to a pre-reaction vessel which communicates at its base with the settling tank, dosing the silt/water mixture with a flocculant, removing settled material from the inlet section of the tank, sweeping settled material along the tank from an outlet section towards such inlet section and discharging substantially silt-free water over an outlet weir.

The invention further extends to a method of washing sand or gravel comprising supplying sand or gravel and washing water to a washing tank allowing washed sand or gravel to settle and removing it from an inlet section of the tank, sweeping settled sand or gravel along the tank from an outlet section thereof to the inlet section for removal, passing used, silt containing water from the washing tank and separating the silt from the water by a method as herein defined.

The argillaceous silt which results from the washing of land-won sand or gravel typically has rather small grain sizes, usually of the order of 75 μm down to zero. Because of this small grain size the silt is extremely slow to settle naturally. The use of a method or apparatus according to the present invention greatly speeds up this process and allows a rapid separation of the silt from the water and without occupying a large area of land. The invention is also of value in the removal of water from slurries resulting from the washing of sea-dredged gravel which slurries are largely sand-based, with a low to moderate content of clay.

In preferred embodiments of the invention there is a said inlet conduit and pre-reaction vessel at each side of the settling tank. This promotes the throughput of the apparatus.

Most preferably, said dosing means is arranged to add said flocculant to the or a said inlet conduit. The flocculant and silt/water mixture are thereby encouraged to mix at an early stage in processing and this promotes settling of the silt, even in the pre-reaction vessel(s).

Advantageously the or a said inlet conduit is fed from a header tank. The use of a header tank promotes continuity of feed of material to the inlet conduit and it also acts to stabilise the pressure head with which the silt-

burdened water is fed to the pre-reaction vessel and thus stabilises conditions within the system.

In some preferred embodiments of the invention the or a pre-reaction vessel at at least one side of the settling tank is in fluid flow communication with a secondary pre-reaction vessel over weir means located therebetween, the or each such secondary pre-reaction vessel also being in communication at its base with the settling tank.

We have found that such a system promotes rapid settling. A substantial proportion of settling of the silt takes place in the primary pre-reaction vessel, and water having a lower burden of silt may pass over the weir into the secondary pre-reaction vessel where a further settling can take place.

In such embodiments it is preferred that the or at least one secondary pre-reaction vessel is in fluid flow communication over weir means with a secondary fluid discharge vessel. The water passing into the discharge vessel may be fed to the settling tank or used for other purposes. In some circumstances the water from the fluid discharge vessel may even be clean enough for passing to the environment.

Advantageously the or at least one said weir means bounding a said secondary pre-reaction vessel is adjustable in height. This facilitates control of the system and promotes cleanliness of the water fed to the secondary discharge vessel.

In preferred embodiments of the invention the base of the or each pre-reaction vessel slopes downwardly towards the inlet section of the settling tank. This promotes the flow of settled silt into the inlet section of the settling tank.

Communication between any said pre-reaction vessel and the settling tank is preferably via a submerged throat. The use of such a throat tends to inhibit return flow of silt from the settling tank into the pre-reaction vessel and it stabilises the settled layer of silt particularly when it is wholly submerged in the silt layer. Preferably means is provided for adjusting the size of such throat to control flow therethrough.

Preferably spraying means is provided for spraying the interior of the or a said pre-reaction vessel for clearing accumulated silt. Such spraying conveniently takes place between runs or at the end of a run when the settling tank is substantially empty and the adoption of this feature allows periodical cleaning of that part of the apparatus.

Advantageously also, spraying means is provided for spraying water onto said removal means for clearing accumulated silt.

The removal means may be sprayed at the end of a run or between runs, or it may be sprayed while the apparatus is in operation.

The spraying means is suitably provided with water which has been separated from silt using apparatus according to the invention. Depending on the circumstances, and the cleanliness of the water which is required for such spraying, the water may be taken from the settling tank from the outlet of the settling tank or from a secondary fluid discharge vessel when such is present. Any of these provides a convenient source of spraying water.

In the most preferred embodiments of the invention the inlet section of the settling tank is deeper than its outlet section. This promotes and facilitates separation and removal of the silt from the water.

In preferred embodiments of the invention the outlet section is of part circular cross-section, and the sweeping means comprises a helical sweeping blade, and means for driving such blade in rotation about its axis. This is a particularly simple and convenient way of keeping the base of the outlet section of the settling tank clear of settled material.

Said removal means preferably comprises a bucket wheel. Such is a simple and convenient way of continuously removing settled silt material from the settling tank.

It will be appreciated that settling is a continuous process and that settlement continues while material is held within a bucket of the bucket wheel. In the result, buckets rising from the settling tank will tend to contain a lower layer of settling silt with a relatively clear layer of water above.

It is desirable that as little water as possible should be withdrawn for discharge with the silt and it is accordingly preferred that said bucket wheel includes buckets which comprise leakage ports for the preferential discharge of water and retention of settled material. Thus, water picked up by the buckets can be allowed to leak back into the settling tank and relatively dry silt is removed.

In the most preferred embodiments of the invention, any leakage ports in a said bucket are confined to an upper region of the bucket. Clearly the upper part of the bucket will depend on where it is on the bucket wheel. When speaking of an upper or lower region of a bucket, we denote the upper or lower region of the bucket when it is in the orientation in which it is capable of retaining the maximum amount of fluid. Depending on the shape of the rim of the bucket, this will usually be at about 90° before the bucket reaches the top of the wheel. Advantageously, any leakage ports

in a said bucket are confined to the upper third of the bucket. In this way, surface water which has accumulated in a bucket due to further settling of silt has the opportunity to run off, and by adopting this feature, we have found that little free water remains in the silt by the stage any given bucket has reached the top of the wheel.

In preferred embodiments of the invention the radially outer face of each bucket is provided with side flanges so as together to define a discharge path for the contents of a next successive bucket. This promotes the discharge from the bucket in a desired direction and helps to minimise inadvertent discharge of the silt back into the settling tank.

Advantageously at least one such side flange is perforated for the preferential discharge of water and retention of settled material. This further promotes separation of water from silt.

It is especially suitable to provide one or more run-off strips in a said radially outer bucket face for guiding liquid to those perforation(s) in a flange.

A canopy may be provided over the bucket wheel, at least over a discharge quadrant of the wheel. The canopy may be of a flexible material which will drape to adapt itself to the outer profile of the wheel. The canopy promotes retention of the silt in the buckets of the wheel until just before they reach the discharge position. Without the canopy the silt from a bucket may cascade over the preceding bucket or buckets. The canopy also restrains the silt from falling to either side of the bucket wheel.

Preferably a sleeve is provided in a said pre-reaction vessel which surrounds said inlet conduit at its outlet end, and which, with said inlet

conduit, defines an annular fluid flow passage. The use of such an inlet sleeve has been found to promote settling of the silt from the water.

Such a sleeve is preferably adjustable in height so as to vary its projection beyond the outlet end of the inlet conduit. This provides a valuable control parameter for varying settling conditions to cater for different silt loading in the water supplied to the apparatus and for other variables in the operating system.

A preferred embodiment of the invention will now be described by way of example only and in greater detail with reference to the accompanying diagrammatic drawings in which:

Figure 1 is an elevational view of an inlet end of a silt and water separating apparatus in accordance with the invention;

Figure 2 is a side elevation of the apparatus of Figure 1;

Figure 3 is a plan view showing the inlet and outlet ends of the apparatus of Figure 1;

Figure 4 is a sectional view through silt removing means viewed in a direction which is opposite to that of Figure 2;

Figure 5 is a detailed view of a silt removing bucket; and

Figure 6 shows a weir arrangement.

With reference to Figures 1 to 3 apparatus for separating silt from water in accordance with the invention comprises a settling tank 1 having an inlet section 2 which is fed by inlet means comprising an inlet conduit 3 leading to a pre-reaction vessel 4 which communicates at its base with the

inlet section 2 of the settling tank 1. The inlet conduit is supplied with a valve 30 and it is also equipped with dosing means 31 whereby a flocculant can be added to a silt and water stream flowing in the inlet conduit 3. A means comprising twin bucket wheels 5 is provided for removing settled material from the inlet section 2 of the tank 1. The tank 1 has an outlet section 6 which has a hemispherical base. A helical screw blade 7 works within that hemispherical base 6 to sweep any settled material along from the outlet section of the tank to its inlet section 2. At the outlet end of the tank 1 cleaned water discharges over a weir 8 to a discharge pipe 9.

Broadly similar apparatus but which omits the inlet conduits 3 and side pre-reaction vessels 4 may be used for washing sand or gravel and such apparatus may in accordance with this invention be arranged to discharge silt laden water to the input of a silt and water separating apparatus as shown in the drawings.

As shown, there is an inlet conduit 3 and pre-reaction vessel 4 at each side of the apparatus. A header tank 10 is provided for the initial receipt of silt laden water and for feeding the inlet conduits 3.

At each side of the settling tank 1 the pre-reaction vessel 4 is in communication with a secondary pre-reaction vessel 11. Communication between these two vessels is over a weir 12. Controls 121 are provided for raising and lowering the weir 12. The secondary pre-reaction vessel 11 at each side of the settling tank is in communication with the tank inlet end section 2 in the same way as the primary pre-reaction vessel 4.

The secondary pre-reaction vessel 11 is likewise in contact over a weir 13 with a secondary discharge vessel 14. Weir controls 131 are provided for these secondary weirs.

The weir control means and weirs are shown in greater detail in Figure 6.

As shown particularly in Figure 1 the bases 41, 111 of the pre-reaction vessels 4, 11 slope downwardly towards the inlet section 2 of the settling tank. The side pre-reaction vessels 4, 11 communicate with the inlet section 2 of the settling tank by means of a submerged throat such as that shown at 16 in Figure 1. Means such as a slide plate 161 may be provided for adjusting the size of such throat to control flow therethrough.

Spray heads 17 are provided for spraying the interior of the pre-reaction vessels 4, 11 after they have been emptied in order to clear accumulated silt which is sticking to their walls. Similarly, spray heads 18 are provided for spray cleaning the buckets of the bucket wheel 5.

As shown in Figure 2 the base 21 of the inlet section of the settling tank is at a lower level than the base 61 of the outlet section 6 of the settling tank. This provides a well in which the bucket wheel 5 can operate for the efficient removal of settled silt material from the apparatus.

As shown particularly in Figures 1 and 3 the inlet conduit 3 is provided with a sleeve 32 where it enters the pre-reaction vessel 4. Each sleeve 32 surrounds the outlet end 33 of the inlet conduit 3, and with that inlet conduit, defines an annular passage 34 for fluid flow.

The sleeve 32 is adjustable in height so as to vary its projection beyond the outlet end 33 of the inlet conduit 3.

The screw 7 for sweeping settled silt material towards the inlet end 2 of the settling tank 1 is driven by drive motor 71 shown in Figure 3. The silt swept by the screw 7 enters the deeper inlet section 2 of the settling

tank where it may be picked up by the bucket wheel 5 and transferred to an outlet discharge chute 19. The material discharge from the outlet chute 19 may fall into a vehicle onto a conveyor or direct to ground. A canopy 20 is provided over the bucket wheels 5 in their discharge quadrant in order to restrain semi solid material from falling into the preceding buckets or to either side of the bucket wheels 5. The canopy 20 may be anchored simply at its upper end, and it may be of a flexible material which will drape to adapt itself to the outer profile of the wheel and so assist in retaining the semi-solid silt in the respective buckets until an appropriate time for discharge into the chute 19.

A bucket wheel 5 is shown in greater detail in Figure 4. As may be inferred from Figure 4 the bucket wheel 5 in this particular embodiment consists of eight sub-assemblies each consisting of three buckets 51 assembled to a support bar 52. The support bars 52 are carried at the end of spokes 53 of the bucket wheel 5. A detail of such a three-bucket sub-assembly is shown in Figure 5. As will be seen in Figures 4 and 5 the radially outer face 54 of each bucket 51 is provided with side flanges 55 and these side flanges and the radially outer face 54 of the bucket 51 together serve to define a guide chute which guides collected silt into the discharge chute 19.

At one or both sides of the bucket wheel such side flange 55 is provided with drainage holes 56 through which water may be discharged to fall back into the inlet section 2 of the settling tank. Guide formations 57 are provided on the external radially outward face 54 of the buckets 51 in order to guide water to those holes 56. The guides 57 may take the form of ridges or of channels as desired. Slots 58 are provided in an upper region of each bucket as shown.

Reverting now to Figure 4 it will be seen that as the wheel 5 rotates in a clockwise direction. Silt which has been picked up by the buckets progressively settles leaving a certain amount of water as a surface layer in each bucket. This water may drain out through slots 58 or small holes provided in an upper region of each bucket. We have defined the expression "upper region" as being the upper region of the bucket when it is in the orientation in which it is capable of retaining the maximum amount of fluid. In the Fig. 4 embodiment, there are 24 buckets so they are spaced at 15°. From inspection of that Figure, it will be apparent that this orientation is that of a bucket between 60° and 75° before it reaches it topmost position T.

When the bucket reaches the uppermost position T on the wheel, or shortly thereafter, the water, which is of course less viscous than the silt material, will flow easily over the radially outer face 54 of the immediately preceding bucket and it can be guided by the guides 54 to flow through the holes 56 in the side flanges 55 and thus flow back into the inlet section of the tank. On further rotation, the wet silt contained in the buckets will flow down between the flanges 55 and will eventually fall into the discharge chute 19.